Claims

1. Plasma treatment process of an object's surface to be treated, comprising the creation of a plasma and the application of the plasma against the surface to be treated, wherein the surface to be treated is excited so that it vibrates.

2. Process according to claim 1, wherein the surface to be treated is excited by means of an external vibration generator.

3. Process according to claim 2, wherein the vibration generator is an ultrasound generator.

4. Process according to claim 2, wherein the vibration frequency of the generator is adjusted to a frequency close to or identical with one of the eigenfrequencies of the object to be treated.

5. Process according to claim 2 in cases of treatment of bottles or other deep containers, wherein vibrations are generated underneath a container bottom opposite to a neck so as to enhance the treatment efficiency on the bottom.

6. Process according to claim 2, wherein an anisotropic etching of the surface to be treated is executed by the generation of vibrations in a particular direction relative to the surface to be treated.

7. Process according to claim 6 in the case of etching treatment of a semiconductor surface, wherein vibrations are executed moving in a direction essentially perpendicular to said surface.

8. Process according to claim 1, wherein the frequency and amplitude of the vibrations of the object to be treated are measured by means of a vibration sensor in order to identify the eigenfrequencies of the object to be treated and/or to verify the excitation of the surface to be treated.

9. Process according to claim 1, wherein the surface to be treated is excited by a shock wave produced during creation of the plasma.

10. Process according to claim 1, wherein the excitation of the surface to be treated is brought about just prior to and/or during and/or just after application of the plasma against the surface to be treated.

11. Process according to claim 1, wherein the plasma is created in a gaseous medium comprising a process gas that can be activated plasma-chemically, the process gas being in contact with the surface to be treated.

12. Process according to claim 1, wherein the plasma is generated by pulses, the lifetime of the plasma generated being longer than the period of undulation of the surface to be treated.

13. Process according to claim 12, wherein the plasma pulse is generated by an essentially adiabatic and isentropic compression of a gaseous medium comprising a process gas that can be activated plasma-chemically.

14. Process according to claim 12, wherein the pulses are generated by incident shock waves and shock waves reflected from the surface to be treated.

15. Process according to claim 12, wherein the pulses are generated by unipolar or high-frequency electrical current pulses.

16. Process according to claim 15, wherein the rise time (t_1) of the electric current amplitude of a pulse is shorter than the ratio d/v of diameter d of the plasma channel created, to the speed of sound v in the gaseous medium surrounding the plasma channel.

17. Process according to claim 15, wherein sonic shock waves are created by an electric breakdown during the creation of a plasma channel or filament.

18. Process according to claim 15, wherein the length (t_2) of an electric pulse is adjusted so as to avoid superficial heating of the surface to be treated, above the critical temperature of instability of the material.

19. Process according to claim 15, wherein the interval between pulses (t_3) is longer than the post-discharge time (t_4) in order to allow a majority of the particles of the surface to be treated, to attain a stable or metastable state.

20. Process according to claim 15, wherein a plasma is created in the form of a branched plasma filament network generating shock waves.

21. Process according to claim 15, wherein the plasma is moved over the surface to be treated, by a relative motion between an electrode and the object to be treated and/or by a magnetic field in motion and/or by a hydrodynamic effect of a process gas in which the plasma is created.

22. Process according to the preceding claim, wherein the pulse length (t_2) is inferior to the ratio between the width of a plasma filament applied to the surface to be treated, and the velocity of motion of the surface to be treated relative to the plasma.

23. Process according to claim 15, wherein a plurality of branched plasma jets distributed over the surface to be treated are simultaneously created and applied.

24. Process according to claim 1, wherein the plasma is fed successively with process gases having different compositions, for different successive treatments of the surface to be treated.

25. Process according to the preceding claim, wherein the process gases include argon, organometallic vapors such as those of silicon and oxygen, and hydrocarbons.

26. Device for the realization of a surface treatment process according to claim 1, comprising a device for plasma generation and an external device for vibration generation.

27. Device for the realization of a surface treatment process according to claim 1, comprising a device for plasma generation and a vibration sensor arranged so as to measure the vibrations emitted by the object to be treated, during the plasma surface treatment process.

28. Device for the realization of a surface treatment process according to claim 1, comprising a device for plasma generation and a laser system that can emit a laser beam across a wall of the object to be treated, and a sensor for the reflected laser beams or laser beams crossing the wall in order to detect the number of photons emitted by non-linear effects during passage of the laser beam across the surface treated, or the decrease in the flux of primary photons caused by their recombination due to non-linear effects.

29. Device for the realization of a surface treatment process according to claim 1, comprising a device for plasma generation and a liquid bath for immersion of the objects to be treated during the plasma surface treatment.

30. Device for the realization of a surface treatment process according to claim 13, further comprising an enclosure with a section intended to house the objects to be treated, and a section of piston chamber, the sections being separated by a piston, the piston being able to be rapidly moved within the enclosure toward the objects to be treated in order to compress the process gas surrounding the objects to be treated to a pressure above the critical pressure of plasma creation in the given process gas.

31. Device for the realization of a surface treatment process according to claim 14, further comprising comprises an enclosure with a section housing the objects to be treated, and a section of a chamber in compression comprising a compressed process gas, where the sections of the enclosure are separated by a wall that can be removed or destroyed.

32. Device according to any one of claims 26, 28 to 31, further comprising a vibration sensor arranged so as to measure the vibrations emitted by the object to be treated, during the plasma surface treatment process.

33. Device according to any one of the claims 26, 27, 29 to 31, further comprising a laser system that can emit a laser beam across a wall of the object to be treated and includes a sensor for the reflected laser beams or laser beams crossing the wall in order to detect the number of photons emitted by non-linear effects during passage of the laser beam across the surface treated, or the decrease in the flux of primary photons caused by their recombination due to non-linear effects.

34. Device according to any one of the claims 26 to 28, further comprising a device for cooling the object to be treated, by a flow or projection of a fluid over the object to be treated.

35. Device according to the preceding claim, wherein the cooling device blows air or another gas over the object to be treated, during or just after plasma application to the surface to be treated.

36. Device according to claim 26, wherein it comprises a liquid bath for immersion of the objects to be treated, during the plasma surface treatment.

37. Device according to claim 27, wherein the device for plasma generation comprises an electrode that can be moved relative to the object to be treated.

38. Device according to claim 27, wherein the device for plasma generation includes an electrode comprising a duct for gas feed.

39. Device according to the preceding claim, wherein the electrode comprises a plurality of gas feed ducts.

40. Device according to claim 38, wherein the electrode comprises a rotating feeding head onto which the duct or ducts of process gas supply for the treatment of essentially axisymmetric containers are mounted.

41. Device according to claim 38, wherein the angle of inclination of the process gas supply ducts is adjustable so that the angle of incidence of the process gas can be adjusted relative to the surface to be treated.

42. Device according to claim 38, wherein the process gas supply ducts for the treatment of essentially axisymmetric containers are essentially arranged in the form of a cone for distributing the process gas in an essentially axisymmetric manner.

43. Device for the realization of a surface treatment process according to claim 1, comprising a device for plasma generation by electric discharge with an electrode in the form of a conducting liquid jet that can be directed against one wall of the object to be treated, on the side opposite to the surface to be treated.

44. Device according to claim 27, further comprising means for recording and checking the plasma parameters during the treatment.

45. Device according to the preceding claim, wherein the means for recording and checking the parameters are able to record and/or check a rising flank of the electric voltage and/or electric current pulse.

46. Device according to claim 44, wherein the means for recording and checking the parameters are able to record and/or check the amplitude and length of the pulses as well as of the pause between pulses.

47. Device according to claim 44, wherein the means for recording and checking the parameters are able to record and/or check the amplitude and frequency of the acoustic vibrations emitted by the object to be treated.

48. Device according to claim 44, wherein the means for recording and checking the parameters are able to record and/or check the temperature of the object to be treated.